CAN WE MODULATE N SUPPLY AND RELEASE FROM GREEN MANURE CROPS?

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Introduction

The fertilisation efficacy of green manure crops depends on species used and crop age at killing date (Guiducci *et al*., 2004; Benincasa *et al*., 2004). Rannels and Wagger (1996) proposed the use of bicultures between leguminous and non-leguminous species as a way to modulate N supply and release according to the requirements of the succeeding cash crop, in order to maximize crop yield and reduce the risk of N leaching. The aim of the present research was to evaluate the fertilisation efficacy for maize of vetch and barley used as green manure monocultures or bicultures at different proportion of their own full seed rate.

Materials and methods

A field experiment was carried out in 2003-2004 in Central Italy (43° N, 165 m a.s.l.) on a clay-loam soil with 1.2% o.m. The experiment consisted of 2 consecutive phases, the first being the cultivation of green manure crops until killing date, the second being the cultivation of maize as a succeeding cash crop.

In a randomized block design with 3 replicates, hairy vetch (*Vicia villosa* Roth., labelled as HV) and barley (*Hordeum vulgare* L., labelled as BA) were compared as pure crops at 100% (HV100, BA100), 75% (HV75, BA75), 50% (HV50, BA50) and 25% (HV25, BA25) of full seed rate (i.e. HV= 90 kg ha^{-1}; BA= 200 kg ha^{-1}) and as bicultures at different proportions of their own seed rate (HV75+BA25, HV50+BA50, HV25+BA75). Green manure crops were sown on 28.10.2003 and killed and immediately incorporated on 5.04.2004.

The experimental design included non green manured plots (i.e. bare soil) to be fertilised at maize sowing with 300 kg N ha^{-1} as urea (N300U) or poultry manure (N300PM) and the unfertilised control (N0).

Maize (cv. Cecilia, FAO class 500) was sown on 27.04.2004 at a density of 9 plants m^{-2} with rows 0.5 m apart.

The following determinations were performed: green manure and maize above-ground biomass and N accumulation at the end of crop cycle, determined by plant sampling and analysis of reduced-N content of dry matter (by an automatic analyser, Flowsys, Systea, on digests prepared according to Isaac and Johnson, 1976); SPAD values of maize leaves during the crop cycle; maize apparent N recovery (REC) calculated according to Greenwood *et al.* (1989); maize grain yield (14% humidity); maize gross income after fertilisation costs (i.e. for green manuring: costs of seed + sowing + biomass cutting up + incorporation; for mineral or poultry manure fertilisation: costs of urea or poultry manure + spreading). Maize was priced 128 € t^{-1} for conventional product and 168 € t^{-1} for organic product (Milan market, November 2004).

Results and discussion

Incorporated biomass (Table 1) increased with seed rate in HV (from 2.4 to 5.4 t ha^{-1}), was little affected by seed rate in BA (5.4 t ha^{-1}, on average), and substancially stable in all bicultures HV+BA (5.5 t ha^{-1}, on average). The amount of N supplied with green manure biomass was quite low in all treatments as compared to that reported by Guiducci *et al.* (2004), and increased linearly with seed rate in HV (from 85 to 166 kg ha^{-1}), while it was not affected by seed rate in BA (66 kg ha^{-1} on average) and HV+BA (111 kg ha^{-1} on average). The SPAD of maize leaves (Fig. 1) changed with green manure species but not with the seed rate: the trend of values was highest in N300U, intermediate in HV, low in HV+BA, and lowest in BA and N0.

Maize N uptake at maturity (Table 1) was always pretty high, also after BA monoculture, and independent of seed rates. This was due to the high basic N fertility of the soil, as indicated by the N uptake in N0 (122 kg ha^{-1}), despite the preceeding crop had been wheat just to deplete soil available N.

The apparent N recovery of maize resulted quite low (REC max = 70%) as compared with that observed in similar experiments (Benincasa *et al*., 2004), due to both the high basic N fertility of the soil and a high spring and autumn rainfall. Among green manure treatments, maize after HV showed the highest REC values, especially at low seed rates, while maize after most BA monocultures showed negative REC values confirming that the incorporation of gramineous biomass with high C/N ratio can immobilize soil N and reduce N availability for the succeeding crop (Rannels e Wagger, 1996).

The grain yield (Table 1) was maximum in N300U and N300PM, lower of 15% in HV, 28% in HV+BA and 33% in BA, as an average over all seed rates.

The cost of fertilisation by green manuring varied only with seed rate and price, with the widest range in HV monoculture (+46% from HV25 to HV100). N300PM was so far the most expensive treatment. The gross income after fertilisation costs (Table 1), in the hypothesis of conventional product, was maximum in N300U, lower of 22% in HV, 38% in HV+BA and 37% in BA as an average over all seed rates. In the organic situation, the income after green manuring came out similar to that of conventional maize fertilised with high urea rate, especially in HV at reduced seed rates. On the contrary, the use of poultry manure at that high rate resulted not convenient. It is also worth to notice that in that soil with pretty high basic N fertility it was even convenient not to carry out any direct fertilisation of organic maize (Table 1).

Table 1. Biomass and N supply to the soil, maize N uptake and apparent recovery (REC), grain yield, fertilisation cost and gross income after fertilisation cost in the hypothesis of conventional and organic product as affected by green manuring and other fertilisation treatments.

Treatments	Green manure supply		N uptake		Grain yield	Fertilisation cost	Gross income after fertilis. cost	
	Biomass (t ha^{-1})	N (kg ha^{-1})	kg ha^{-1}	REC%	(t ha^{-1})	(€ ha^{-1})	Conventional (€ ha^{-1})	Organic (€ ha^{-1})
N0	–	0	122	–	9.2	0	1173	1545
N300PM	–	300	223	34	12.1	1445	94	583
N300U	–	300	252	43	12.2	183	1372	–
HV100	5.5	166	162	24	10.1	323	967	1377
HV75	5.2	132	181	44	10.2	274	1028	1441
HV50	4.1	116	201	68	11.1	224	1197	1649
HV25	2.4	85	182	70	9.8	175	1075	1472
BA100	5.4	63	115	-11	8.3	203	850	1184
BA75	6.2	72	104	-24	7.8	184	810	1125
BA50	5.6	73	115	-10	8.4	164	901	1239
BA25	4.4	56	124	3	8.1	145	893	1223
HV75+BA25	5.6	127	142	20	9.7	293	942	1334
HV50+BA50	5.5	104	110	3	8.0	263	759	1084
HV25+BA75	5.4	102	152	30	8.5	233	852	1197
LSD (P = 0.05)	1.35	28.0	63.0	48.2	1.83	–	233.0	307.0

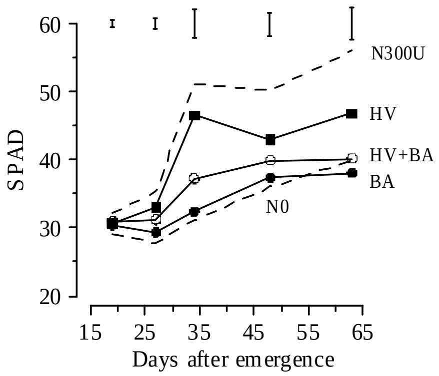

Fig. 1. Time course of SPAD values of maize leaves. Bars represent *pooled* SEs at each date of measurement.

Results indicate that a certain modulation of N availability from green manuring can be achieved by acting on species and seed rates to be used in both monocultures and bicultures. However in the year of experiment the modulation was less fine than expected due to both the pretty low N accumulation of vetch and the high basic N fertility of the soil that partly masked the effect of different N supply from green manure treatments. These results, joined to those of previous experiments (Guiducci *et al.*, 2004) confirm that green manuring fertilisation efficacy can change across years depending on season climate and soil. In any case it comes out that, even in a year with a pretty low N supply from green manuring, the technique can be economically sustainable in an organic production frame, provided the price of organic product rules higher than the conventional one.

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